



# Simulation of Photons Attenuation in Overburden

Kevin Lee  
UCLA

Mar 11-12, 2006 NOvA Meeting



# Background Estimates

Leon's novadoc 409-v2

The numbers are for Supernova detection with continuous cycle!

Depth	Signal	EM bkd	Neutron	S/sqrt(b)
0m	1500	10,000	3,000	13
1m	1500	1800	424	30
2m	1500	320	60	77
3m	1500	57	8.5	185
4m	1500	10	1.2	450

Mar 11-12, 2006 NOvA Meeting

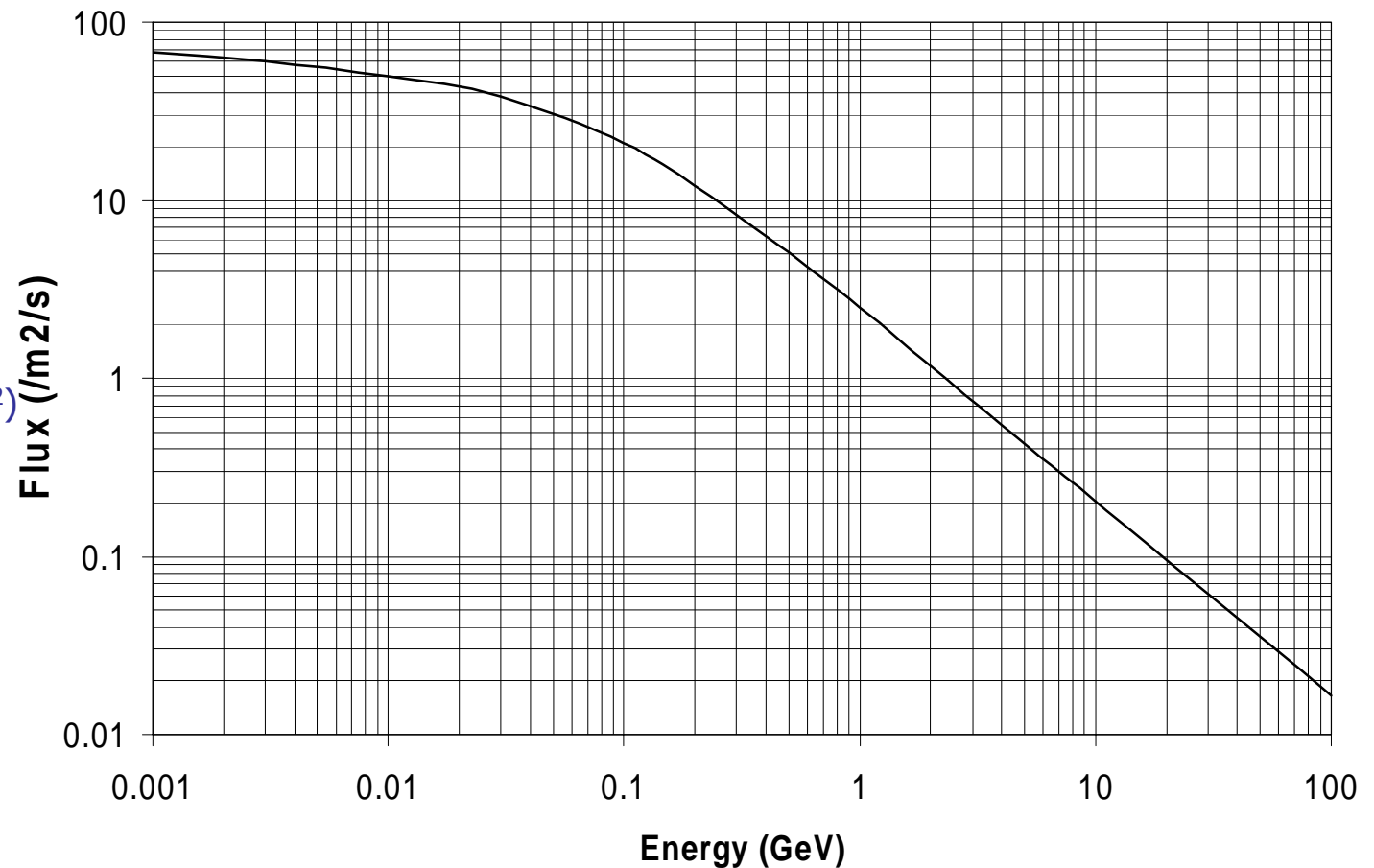
Leon Mualem



# Electrons and photons

## Integral electron and photon flux at surface

- Data from Daniels and Stephens; Revs Geophys. And Space Sci. 12, 233(1974)
- $\sim \cos^2\theta$  for  $\theta < 60^\circ$
- Median energy " 10s of MeV
- Attenuated as  $\sim \exp(-x/175\text{g.cm}^{-2})$



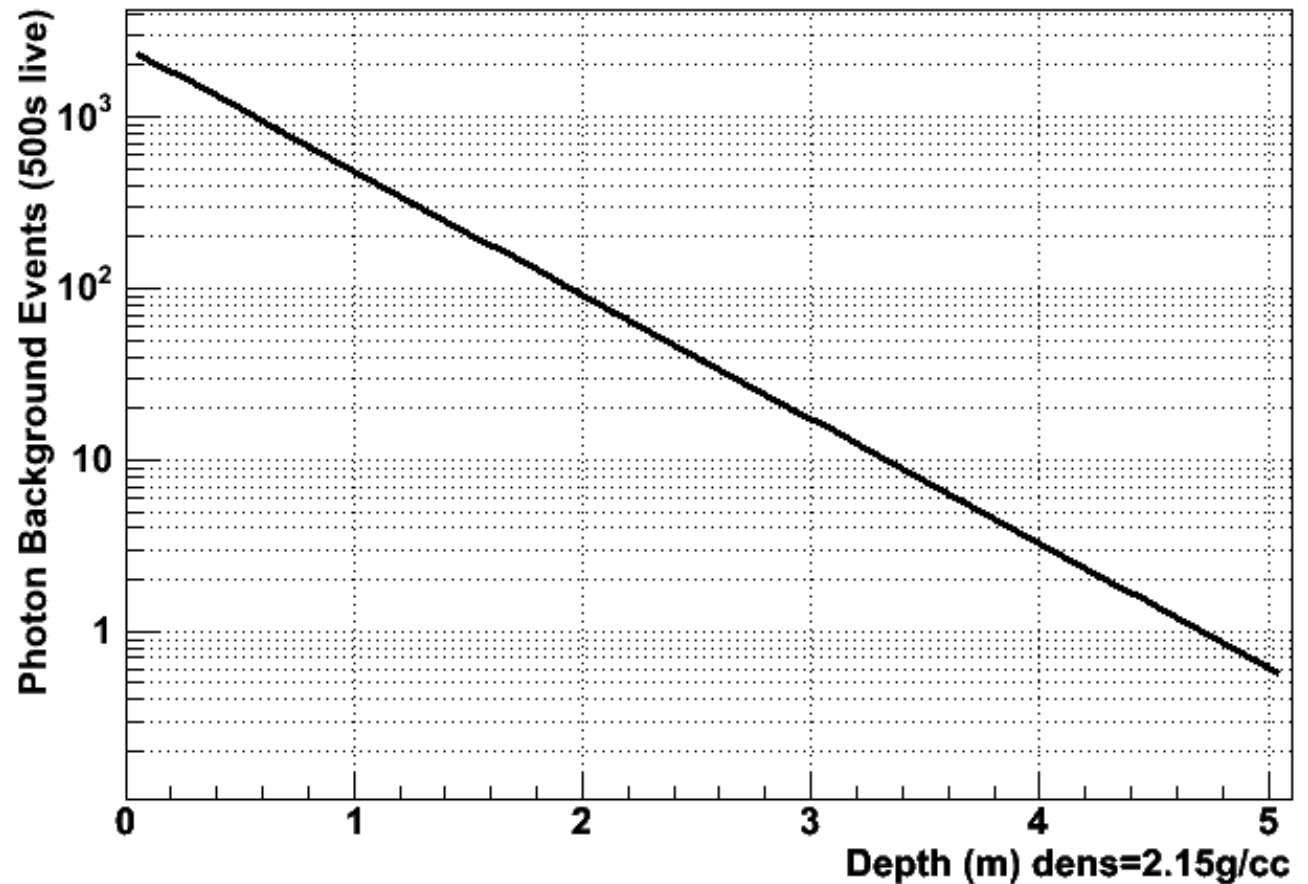
Mar 11-12, 2006 NOvA Meeting

Leon Mualem



# Photon background vs. Overburden depth

- Reduction from 2560 events of photon background vs. depth

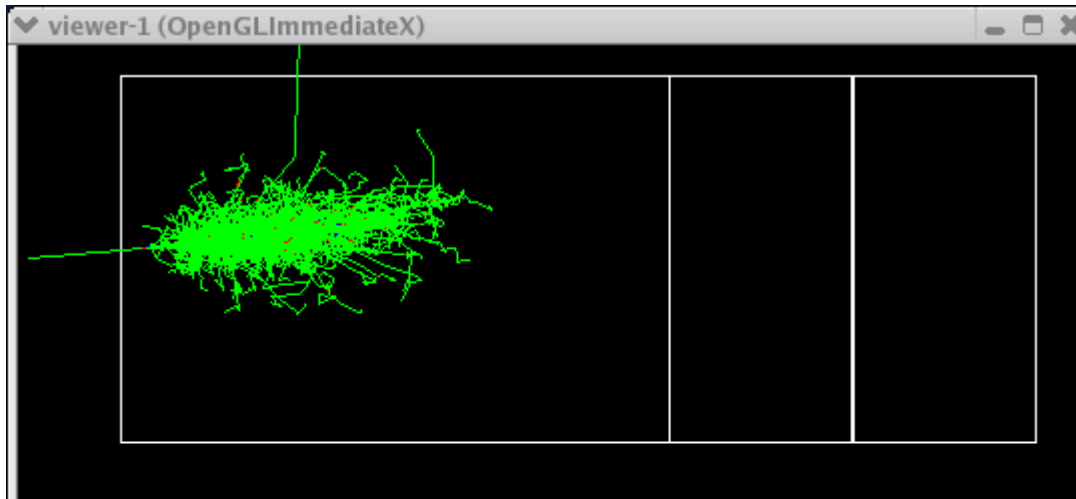


Mar 11-12, 2006 NOvA Meeting

Leon Mualem



# Simple Geometry Studies



- 5 GeV gamma
- Forming a shower in less than 0.5 m depth
- farthest left block is 2 gm/cc Earth

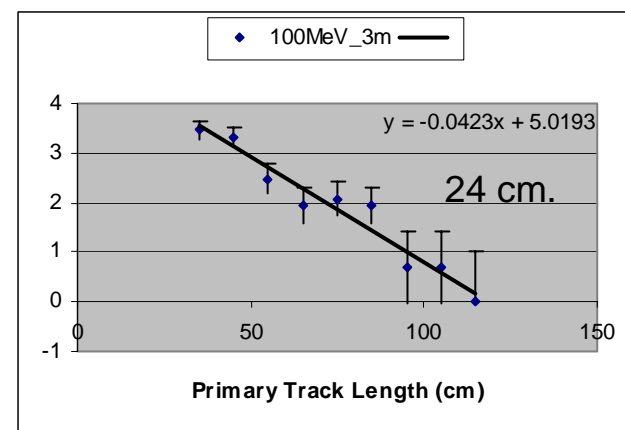
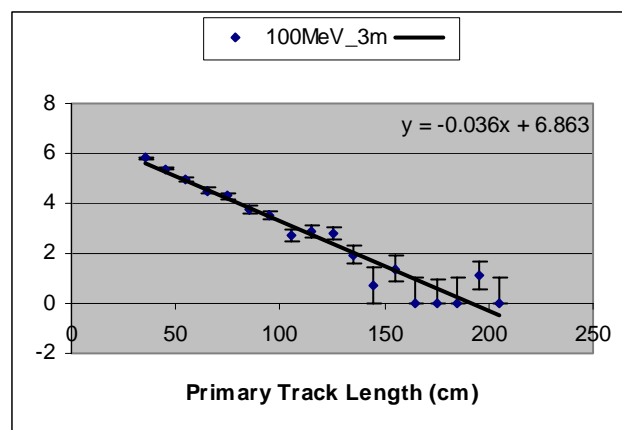
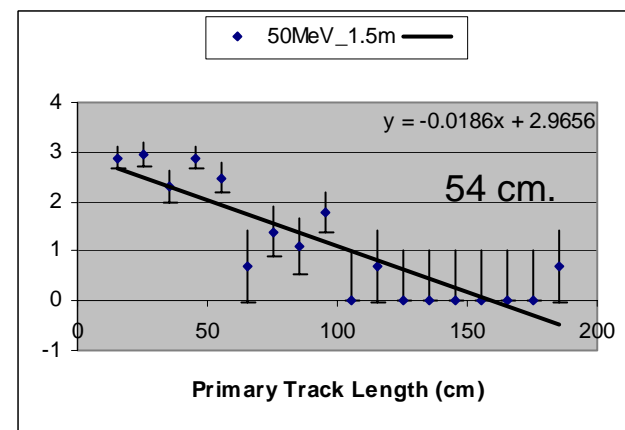
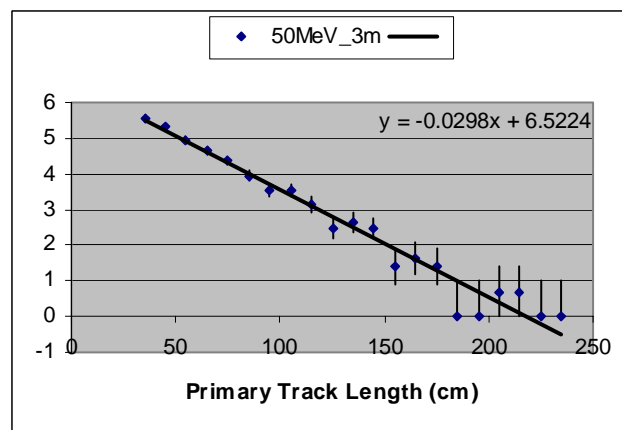
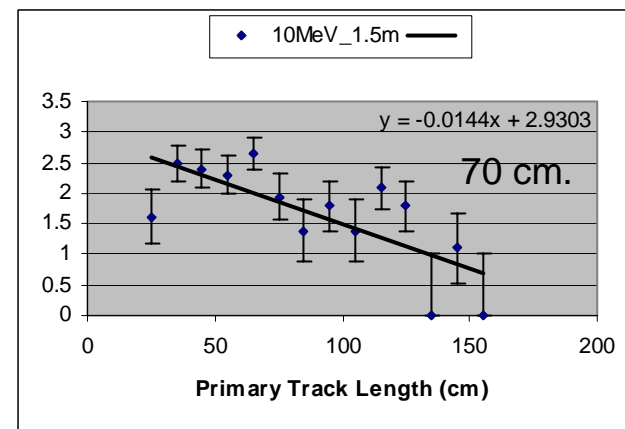
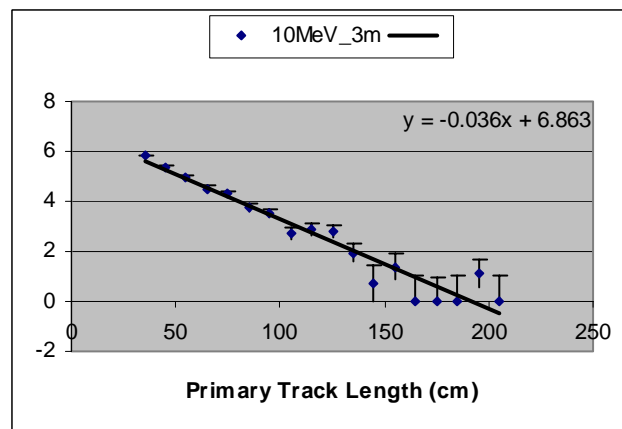
- A series of Geant4 runs is done for a simple geometry of slab layers of Earth's crust composition, for different gamma photon energies directed perpendicular to the slabs.
- The density used is 2 g/cc and should be higher, but no more than ~5 g/cc.
- There are large showers beyond the primary tracks.



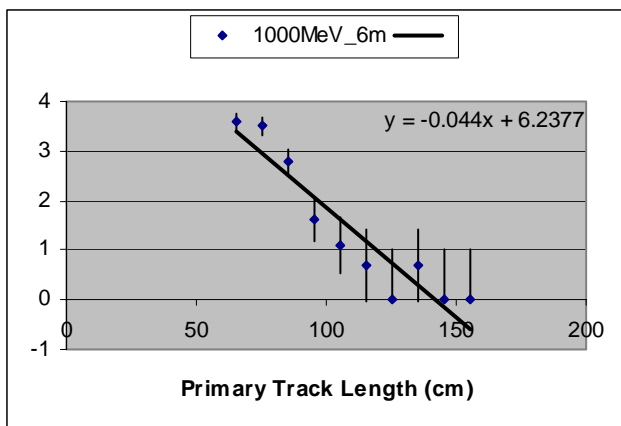
10 MeV:  $\rho = 2 \text{ g/cc}$ ;  
 $\lambda = 27.8 \text{ cm}$

50 MeV:  $\rho = 2 \text{ g/cc}$ ;  
 $\lambda = 33.6 \text{ cm}$

100 MeV:  $\rho = 2 \text{ g/cc}$ ;  
 $\lambda = 27.8 \text{ cm}$

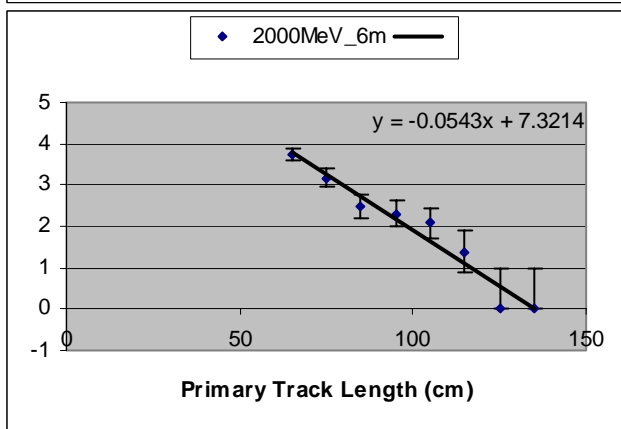


Mar 11-12, 2006 NOvA Meeting



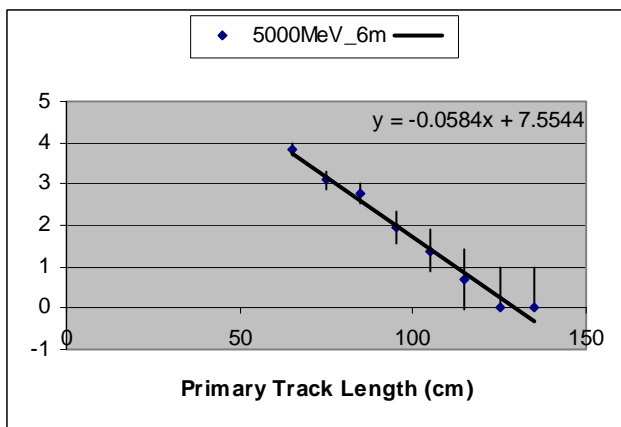
10 MeV:  $\rho = 2 \text{ g/cc}$ ;

$\lambda = 23 \text{ cm}$



50 MeV:  $\rho = 2 \text{ g/cc}$ ;

$\lambda = 18 \text{ cm}$ .



100 MeV:  $\rho = 2 \text{ g/cc}$ ;  $\lambda = 17 \text{ cm}$

Overburden (L. Mualem)

Attenuation length at 1 GeV:  
 $\sim 125 \text{ g/cm}^2$  ;  $\sim 60 \text{ cm}$



## Summary

- The plots are  $\ln(N)$  vs. primary track lengths to show an attenuation of the primary tracks through the layers below 50 cm.
- There are gammas,  $e^-$  and  $e^+$  in the shower plumes always and [physicswise] also pions above for primary gammas above 140 MeV.
- In the far detector concept with an overburden, cosmic gamma photons can be attenuated
- If the  $\lambda \sim 30$  cm is value, then 150 times with a 1 1/2 m overburden as long as the subsequent showers of charged particles can be discriminated by the NOvA detector.
- Ongoing: track lengths of tertiaries of gammas and  $\pi^0$ 's